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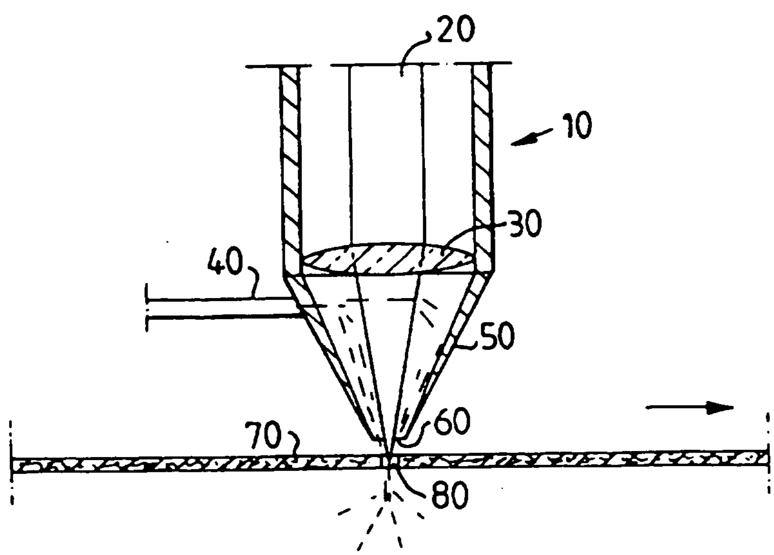
(54) Title: A METHOD FOR PRODUCING HOLES OR SLOTS IN LAYERS OF MATERIAL INTENDED FOR ABSORBENT ARTICLES WITH THE AID OF RADIATION ENERGY

(57) Abstract

A method for forming through apertures in the form of holes and/or slots or slits in a web which is intended to form part of absorbent articles, wherein the web is irradiated with at least one focused electromagnetic beam or particle beam from an irradiating source on at least one of its surfaces and in those web regions in which the apertures are to be formed, wherein the properties of the beam and the duration of the irradiation period are selected so that the material will receive in these regions sufficient energy to melt and/or vapourize and/or pyrolyze and/or burn said material, and wherein resultant molten and/or vapourized and/or pyrolyzed and/or combusted material is esssentially removed.



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A METHOD FOR PRODUCING HOLES OR SLOTS IN LAYERS OF MATERIAL INTENDED FOR ABSORBENT ARTICLES WITH THE AID OF RADIATION ENERGY

TECHNICAL FIELD

The present invention relates to a method for producing through appertures in the form of holes and/or slots or slits in a web, preferably a web having a weight per unit area of about 5-100 g/m^2, more preferably 10-50 g/m^2, said web including polymeric and/or cellulosic material and being intended for use in absorbent articles. The present invention also relates to a method of making appertures in such a web while, at the same time, joining the web to another web of similar material. By "cellulosic" is meant here that the material can include larger or smaller amounts of cellulose fibres.

Absorbent articles, which term includes diapers, sanitary napkins, incontinence guards, panty protectors, etc., are known to the art in many different designs. These articles always include at least one absorbent body and at least one top sheet or layer which is intended to lie proximal to the wearer.

One problem associated with the manufacture of such articles relates to controlling the liquid-permeability of the top sheet. Considering all other requirements placed on material from which such sheets are produced, for instance with regard to mechanical strength, softness and elasticity, it is far from evident that the liquid-permeability required is an inherent property of the material used. It is therefore often necessary to provide the top sheets with appertures in the form of holes and/or slits or slots in order to obtain the required permeability. One advantage afforded hereby is that different areas of the sheets can be given different degrees of permeability, which is desi-

rable in the case of some applications, simply by providing certain areas with more appertures than others.

Appertures are also often provided for the purpose of forming so-called tear lines, i.e. perforations arranged sequentially in rows along lines or curves along which the material is intended to be torn apart when sufficiently large, counteracting forces are applied on respective sides of the material.

There are also other cases and applications well known to the person of normal skill in this art in which it is necessary or at least desirable to provide appertures in web materials of the aforesaid kind.

As before mentioned, it is often difficult to find material which will fulfil all of the requirements that are placed on material intended for use in absorbent articles. It is therefore usual to join together or to laminate different materials, so as to obtain a combined material sheet, a laminate, which will fulfil these requirements to a greater extent.

DESCRIPTION OF KNOWN TECHNIQUES AND THEIR PROBLEMS

A known technique for forming appertures in material webs of the aforesaid kind comprises subjecting the material to conventional treatment with the aid, for instance, of pin rolls or drums while supplying heat, or with the aid of different types of punches or dies. Among the more modern methods of providing such appertures are those which are based on the use of ultrasound and powerful water jets (so-called water jet technique). One particular method of forming holes in plastic film with the aid of perforated rolls and applied vacuum conditions is described in US-A 3,929,135, for instance. A common feature of all the known methods is that they are of a mechanical character. When

working the web, the web is always in direct physical contact with materia which will transfer the amount of energy required to form said appertures.

One of the main problems of known techniques is the apparent lack of flexibility that results from the fact that the appertures are formed precisely by direct contact with materia. In order to change the size and/or the mutual relationship between the appertures that are formed, it is necessary either to halt production and exchange a pin roll or, when ultrasound is used, a pattern roll. In keeping with the laws of nature, it is impossible to regulate, for instance, the speed or temperature of an RDC drum in discrete stages. Because of the inertia of the mass, adjustments can only be made continuously between the different stages. Consequently, when wishing to change the hole-forming control parameters during ongoing production in accordance with known techniques, it is necessary to accept the fact that a large part of the web will not meet the specifications that have been laid down, i.e. that part of the web which passes by before the control parameters have taken their new values, and must therefore generally be scrapped. The inertia of the energy-transferring materia also constitutes a problem insomuch that it has a highly limiting effect on production rate, because the inertia of the materia limits the speed at which the necessary mechanical and possibly also thermal hole-forming energy can be delivered to the material. The water jet technique is also encumbered with these drawbacks.

With regard to forming holes in web material intended for use in absorbent articles, the known technique is also encumbered generally with a further drawback. The material located around the appertures is compressed, for instance by an RDC drum or by the pattern drum or roll of an ultrasonic device. This compression will, of course, often have

a significant negative effect on the properties of the material, such as softness, flexibility and so on.

No methods which combine the steps of laminating webs and forming holes in one of the webs are found in the known technique. Lamination is effected in a separate stage and is performed conventionally by gluing or ultrasonic-welding. Naturally, from a production/economic aspect, it would be desirable to refrain from this additional stage of manufacture and still obtain an equally as good or better product.

The Invention

The main object of the present invention is to provide a method of the kind defined in the introduction which is essentially free or totally free of the drawbacks associated with known techniques.

Another object is to provide such a method which will afford the advantage of enabling the web in which the holes are formed to be joined, laminated, with another material of a similar kind.

These objects and advantages, together with others obvious to the person skilled in this art, are achieved with a method of the kind defined in the introduction which has the characteristic features set forth in the characterizing clause of the following Claim 1.

The use of focused electromagnetic beams or particle beams for hole-forming purposes affords a number of advantages. The point of attack or impingement of such a beam (i.e. the point at which the beam impinges on the substrate) can be readily changed with the aid, for instance, of a system of mirrors, prisms and/or magnets, which in this context may be referred to as "magnetic mirrors". Mirrors and prisms

have a relatively small mass and thus present only a small degree of inertia against movement, therewith enabling the beam impingement point to be moved rapidly and with very small energy consumption. Naturally, in relation to known techniques this affords considerable advantage with regard to the flexibility with which control parameters can be changed. With a mirror/prism system, it is possible to cause the beam to pass very quickly from forming one pattern of holes in a web to forming holes in accordance with another pattern. By controlling the mirror/prism system with the aid of a computer, a very high degree of freedom is obtained with regard to the selection of different patterns, these being attainable immediately after having been selected. Instead of needing to halt the web in order to change rolls, drums and the like, which is necessary when practicing known techniques and which is clearly a troublesome procedure, the control parameters can be adjusted with the aid of a computer program and by guiding or controlling the mirror or prism system electronically while production proceeds undisturbed, since the control parameters will adopt their new values almost immediately. The mirror systems of the aforesaid kind described in DE-A1-3,300,822, EP-A1-0,179,275 and EP-A2-0,477,458 are among those that can conceivably be used in the present context. A conceivably usable system with so-called kinoform is described in SE 9201056-0. Other conceivable systems, which are actually intended for laser engraving processes, are described in DE-A1-4,212,390 and DE-C2-3,332,838.

The focused beam used in the inventive process will transmit energy at much higher power per unit area than in the case of the known techniques, in other words the energy supply per time and unit area is considerably greater. This enables the speed of the web, and therewith the production rate, to be increased to roughly twice the speed, or higher, than that which can be achieved with the known techniques.

Since the energy supply is highly concentrated at those locations at which appertures ar to be formed, very well-defined appertures are obtained in the absence of undesirable compression of surrounding material.

The focused beam may be a beam of charged or neutral particles, or may be a light beam, such as a coherent or non-coherent, or monochromic or polychromic light beam respectively.

According to one preferred embodiment of the present invention, there is used a beam of coherent electromagnetic radiation, preferably a laser beam, and more preferably a beam generated by a CO_2 laser, since the wavelength range of beams emanating from a CO_2 laser is such that the efficiency is very high for converting radiant energy to heat in the material concerned (different polymers and cellulose), i.e. the applied energy is utilized very effectively to form holes in the material.

According to the inventive method, a fluid, preferably a gas, may be delivered to the vicinity of the focusing point on the web and optionally adjacent occurrent focusing means. The flow of fluid functions to remove molten/burned/-vapourized material from holes made in the web, and also to cool the edges of the holes so as to reduce the heat-affected zone around the holes, and also functions to cool occurrent focusing means, such as lenses and the like. A fluid commonly used in this regard is air. When a more rapid hole-forming process is desired, there can be used a gas which has a relatively high oxygen content, since this will favour burning of the web material at the focusing point. When wishing to reduce the risk of charring the edges of the holes and therewith discolor the material, an inert gas, such as nitrogen or argon, can be used instead. It may also be appropriate to use an inert gas when the web contains a high proportion of cellulose.

The through appertures may be permeable to both liquid and vapour, although they are preferably intended to allow liquid to pass through.

According to one embodiment, the web material is plastic film or plastic foil, while in another embodiment the web material is a bonded-fibre fabric or a sheet of nonwoven material.

The appertures may be holes having a diameter of up to 4 mm, preferably from 0.3-3 mm, more preferably from 0.5-1.5 mm, or slots having a length of up to 10 mm, preferably up to 5 mm. The slots may be straight or more or less curved and may also intersect or break one another.

According to one particularly preferred embodiment of the present invention, when irradiating the web the web is in contact with another web which includes material of a kind similar to the first web and which is located on that side of the first web that lies opposite to the irradiation source, and the properties of the beam and the duration of the irradiation period are chosen so that the material in the first web and/or in the further web will be supplied with sufficient energy to join the webs together in the immediate vicinity of the appertures. In this way, holes are formed in one web while laminating the webs together at the same time. As will be understood, this is a technical advance of very great significance. When practicing the present invention, it is unnecessary to perform a separate laminating stage, which naturally implies a considerable economic advantage. In relation to known techniques, there is also obtained improved contact between the webs, which is favourable to absorption and also to the transportation of liquid through the laminate.

The present invention will now be described in more detail with the aid of examples and also with reference to the accompanying drawings, in which

Fig. 1 illustrates schematically an embodiment of an inventive method for forming appertures in a web of material intended for the production of absorbent articles;

Fig. 2 illustrates schematically an embodiment of the invention, wherein appertures are formed in a web while at the same time joining the web to another web; and

Fig. 3 is an enlarged view of the encircled region in Fig. 2.

Like reference signs have been used to identify like objects in the different Figures.

Fig. 1 is a sectioned view of part of a laser 10 which generates a laser beam 20, which is focused with the aid of a focusing lens 30. The beam 20 diffracted by the lens 30 passes through a nozzle 50 and leaves the nozzle through an apperture 60. A shielding gas delivered through a conduit 40 flows through the space defined by the lens 30 and the walls 50 of the nozzle. The beam impinges on a web of material 70, so as to make an apperture 80 in the web.

The laser device 10 of the Fig. 2 illustration is of the same kind as that shown in Fig. 1, although in this case, the laser is used to form holes or appertures in an upper web 70 while simultaneously joining the web to a lower web 90.

As will be seen from Fig. 3, part of the material that has melted when making the hole 80 in the web 70 forms a joint 100 between the webs 70 and 90.

Example 1

Given below are a number of examples of tests carried out in accordance with the illustrated embodiments of the present invention. These tests were carried out with the aid of a CO_2 laser (gas laser) marketed under the trade name LASAG, production designation COL 200, which delivers a laser beam which is directed essentially vertically downwards onto the material to be worked and which had a wavelength of 10.6 μm. In this test, the material was placed on a table which could be moved along two axes and which was controlled by a programmable CNC system known by the trade name BOSCH®. Prior to being focused, the laser beam had a diameter of about 7 mm, a beam divergence of about 1.5 mrad, and an approximate gaussic power distribution across the beam cross-section; in focus the beam diameter is about 60 μm. The focusing lens had a focal length of about 38 mm. The shielding gas used was air at a gauge pressure of 0.1-0.5 bars. The exit opening of the gas nozzle had a diameter of about 1.5 mm and when working the web was located at a point about 1.5 mm above the focal plane, which in turn was located at a point about 3 mm above the surface of the material to be worked.

Table I below presents the results obtained with a number of tests in which holes were formed in different sheet or surface materials with the aid of the aforesaid equipment. The materials used were

B7W	=	Spunbonded polypropylene with wetting agent, weight per unit area 15 g/m^2.
N9W	=	Spunbonded polypropylene without wetting agent, weight per unit area 23 g/m^2.
ESC	=	Carded and thermobonded bicomponent material of polyethylene/polypropylene, weight per unit area 23 g/m^2.

V180 = Carded and thermobonded polypropylene material, weight per unit area 22 g/m^2.

The terms given in Table I have the following meaning:

Pulse rep. time	=	Time between each laser pulse.
Mean power	=	Time mean value of the power of the transmitted laser beam.
Focus distance	=	Distance from the focal plane of the diffracted laser beam, to the surface of the irradiated material.
Spacing	=	Distance between the holes.

The remaining terms will be self-evident. The table carrying the material was moved at a speed of 167 mm/s in both the x-direction and the y-direction in all tests.

Table I

Test	Material	Mean power	Pulse time	Pulse rep. time	Pulse power	Focus dist.	Spacing	Spacing	Gas pressure	Hole diameter
No.	code	W	ms	ms	W	mm	in the x-direction, mm	in the y-direction, mm	bar	mm
1	B7W	23	0.5	7	322	1.5	1.17	1	0,1	0,6
2	B7W	23	0.5	7	322	2	1.17	1	0.2	0.55
3	B7W	23	0.5	7	322	2	1.17	1	0.3	0.55
4	B7W	28	0.5	5.6	314	1	0.94	0.8	0.3	0.5
5	B7W	28	0.5	5.6	314	1	0.94	0.8	0.3	0.5-0.55
6	B7W	28	0.5	5.6	314	1	0.94	0.8	0.4	0.4
7	B7W	28	0.5	5.6	314	1	0.94	0.8	0.4	0.35-0.4
8	B7W	28	0.5	5.6	314	0.5	0.94	0.8	0.5	0.35
9	B7W	28	0.5	5.6	314	0.5	0.94	0.8	0.5	0.35
10	B7W	28	0.5	5.6	314	0.5	0.94	0.8	0.5	0.4
11	B7W	27	0.5	8	432	2	1.34	1.2	0.3	0.7
12	B7W	27	0.5	8	432	2	1.34	1.2	0.3	0.65
13	N9W	27	0.5	8	432	2	1.34	1.2	0.3	0.5

to be continued

Table I. cont.

Test	Material	Mean power	Pulse time	Pulse rep. time	Pulse power	Focus dist.	Spacing	Spacing	Gas pressure	Hole dia-meter
No.	code	W	ms	ms	W	mm	in the x-direction	in the y-direction	bar	mm
14	N9W	31	0.5	8	496	2	1.34	1.2	0.3	0.6
15	N9W	25	0.5	7	350	2	1.17	1	0.4	0.6
16	N9W	25	0.5	7	350	1	1.17	1	0.4	0.35
17	N9W	25	0.5	7	350	1	1.17	1	0.4	0.3
18	N9W	25	0.5	7	350	1.5	1.17	1	0.4	0.45
19	ESC	25	0.5	7	350	1.5	1.17	1	0.4	0.45
20	ESC	25	0.5	7	350	1.5	1.17	1	0.4	0.55-0.65
21	ESC	25	0.5	7	350	1.5	1.17	1	0.4	0.5-0.55
22	ESC	25	0.5	7	350	1.5	1.17	1	0.4	0.45
23	ESC	25	0.5	7	350	2	1.17	1	0.4	0.55
24	ESC	25	0.5	7	350	2	1.17	1	0.3	0.55
25	ESC	25	0.5	7	350	2	1.17	1	0.3	0.4-0.5
26	V180	7	0.5	11	154	3	1.84	1.2	0.3	0.65
27	V180	8.5	0.5	11	187	3	1.84	1.2	0.3	0.65
28	V180	7	0.5	11	154	3	1.84	1.2	0.3	0.65
29	V180	7	0.5	11	154	2.5	1.84	1.2	0.3	0.5

It will be evident from tests 26-29, for instance, that it is possible to produce in polypropylene sheet material holes having a diameter of 0.5-0.65 mm with the aid of a laser which has a mean power of 7-8.5 W and which delivers a laser pulse with a time duration of 0.5 ms. A pulse repetition time of 11 ms means that it is possible to form 91 holes per second (1,000 ms/7 ms/hole). With lasers which have mean powers in the order of 20 kW, i.e. a power of about 2,580 times the power of the aforesaid test laser, it is thus possible to produce about 230,000 holes/second when the laser beam is divided with the aid of a mirror, prism or kinoform system. This number of holes shall be compared with the number of holes that can be achieved with conventional techniques, which is about 100,000 holes/second.

Example 2

Table II below presents the results obtained from a number of tests carried out with combined holes forming in surface material while simultaneously joining the material to another similar material with the aid of the aforesaid equipment. These materials were:

B9W = Spunbonded polypropylene with wetting agent, weight per unit area 20 g/m^2 (surface material in the tests).

L4-601 = Carded and thermobonded bicomponent material consisting of polyethylene/polyester, weight per unit area 50 g/m^2 (spacing material in the tests).

The speed given in Table II relates to the speed of the movable table in the X-direction.

Table II

Test	Material	Mean power	Pulse time	Pulse rep. time	Pulse power	Focus dist.	Spacing	Speed	Gas pressure	Hole diameter
No.	code	W	ms	ms	W	mm	in the x-direction. mm	m/min	bar	mm
30	L4-601/B9W	50	0.5	2.5	250	0	1.5	36	0.5	0.5
31	L4-601/B9W	30	0.5	3	180	0	1.4	28	0.5	0.5

It will be understood that the aforedescribed embodiments and examples do not limit the scope of the present invention, which is limited solely by the following Claims, which encompass several other embodiments conceivable to the person skilled in this art.

CLAIMS

1. A method for forming through appertures in the form of holes and/or slots or slits in a web to be included in absorbent articles, **characterized** in that the web is irradiated with at least one focused electromagnetic beam or particle beam from an irradiating source on at least one of its surfaces and in those web regions in which the appertures are to be formed, wherein the properties of the beam and the duration of the irradiation period are selected so that the material will receive in these regions sufficient energy to melt and/or vapourize and/or pyrolyze and/or burn said material; and in that resultant molten and/or vapourized and/or pyrolyzed and/or burnt material is essentially removed.

2. A method according to Claim 1, **characterized** in that the beam is a laser beam.

3. A method according to Claim 1 or 2, **characterized** in that the web has a weight per unit area of 5-100 g/m^2.

4. A method according to Claim 3, **characterized** in that the web has a weight per unit area of 10-50 g/m^2.

5. A method according to any one of the preceding Claims, **characterized** in that the appertures are intended to allow liquid to pass through.

6. A method according to any one of the preceding Claims, **characterized** in that the web is intended for use as the top sheet of an absorbent article.

7. A method according to any one of the preceding Claims, **characterized** in that the appertures are in the form of holes having a diameter of up to 4 mm.

8. A method according to Claim 7, **characterized** in that the holes have a diameter of 0.3-3 mm.

9. A method according to Claim 7, **characterized** in that the holes have a diameter of 0.5-1.5 mm.

10. A method according to any one of Claims 1-6, **characterized** in that the appertures are slots or slits having a length of up to 10 mm.

11. A method according to Claim 10, **characterized** in that the slots have a length of up to 5 mm.

12. A method according to any one of the preceding Claims, **characterized** in that the web consists of a plastic film or plastic foil.

13. A method according to any one of Claims 1-11, **characterized** in that the web consists of bonded-fibre fabric or a layer or sheet of nonwoven material.

14. A method according to any one of the preceding Claims, **characterized** in that when irradiating the web, the web is in contact with another web which includes material of a kind similar to the first web and which is located on that side of the first web which lies opposite to the irradiation source; in that the beam properties and the duration of the irradiation period are chosen so that the material in the first web and/or in the other web will receive sufficient energy to join the webs together in the immediate vicinity of the holes and/or the slots or slits.

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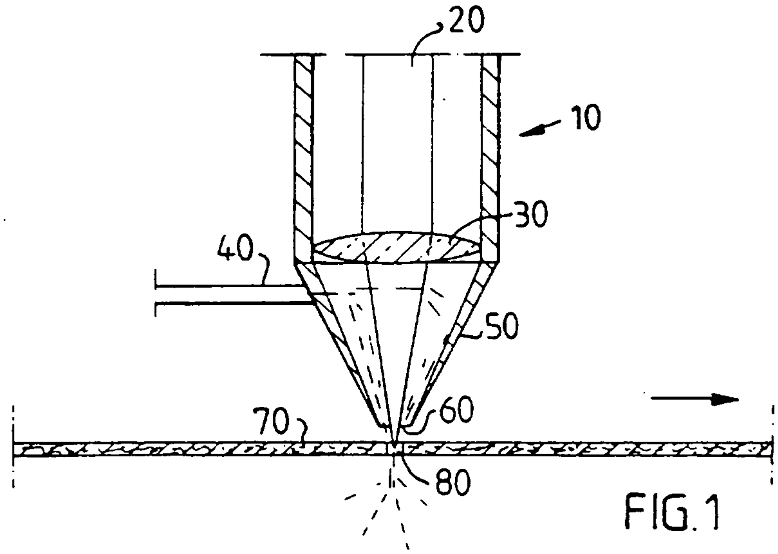

FIG.1

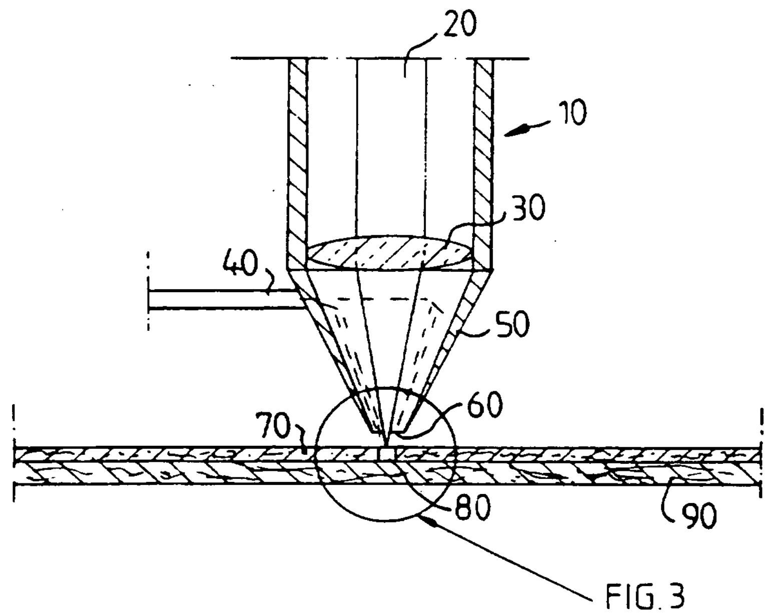

FIG. 2

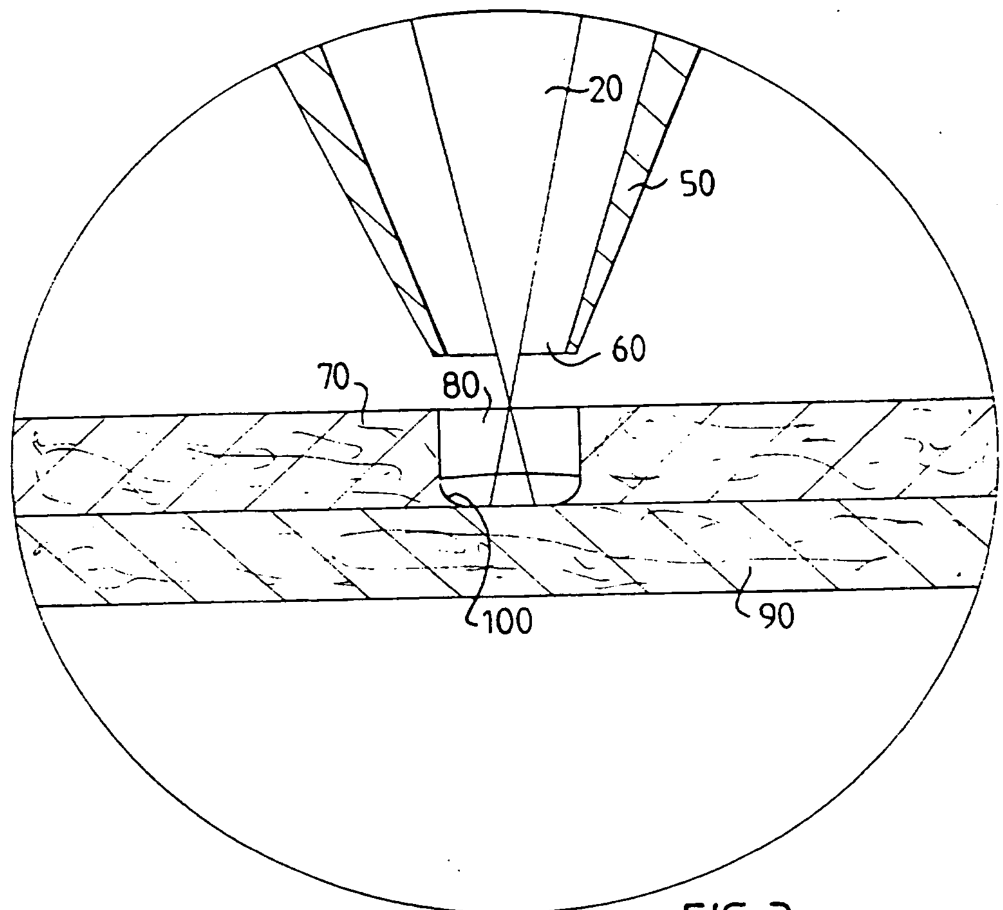

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 95/01522

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B23K 26/00, B29C 65/74, A61F 13/15
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B29C, A61F, B23K, B26F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0549357 A1 (POLYMER PROCESSING RESEARCH INSTITUTE LIMITED), 24 December 1992 (24.12.92) --	1-14
A	WO 9401070 A1 (E.I. DU PONT DE NEMOURS AND COMPANY), 20 January 1994 (20.01.94) --	1-14
A	DE 4333877 A1 (HOESCH INDUSTRIELASER GMBH), 26 May 1994 (26.05.94) --	1-14
A	GB 1121057 A (NATIONAL RESEARCH DEVELOPMENT CORPORATION), 24 July 1968 (24.07.68) -- --------	1-14

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Date of the actual completion of the international search	Date of mailing of the international search report
11 April 1996	18.04.1996
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